(19) Europäisches Patentamt
European Patent Office
Office uropéen d s br vets

(11) EP 0 995 496 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
26.04.2000 Bulletin 2000/17

(51) Int Cl.7: B04B 1/00, B04B 1/08, B04B 5/00, B04B 7/08

(21) Application number: 99308286.6

(22) Date of filing: 20.10.1999

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 20.10.1998 US 175981

(71) Applicant: FLEETGUARD, INC.
Nashville, Tennessee 32717 (US)

(72) Inventors:
- Herman, Peter K.
  Cookeville, Tennesee 38506 (US)
- Weston, Donald
  Algood, Tennesee 38501 (US)

(74) Representative:
Everitt, Christopher James Wilders et al
fJ CLEVELAND
40/43 Chancery Lane
London WC2A 1JQ (GB)

(54) A centrifugal separator

(57) A centrifugal separator (20) for removing particulate matter from a fluid includes a base (30) defining inlet (41), an outer shell (31) assembled to the base (30), a stationary centertube (34) assembled to the base (30), and a rotor assembly (20a) which is mounted onto the centertube (34) and positioned within the outer shell (31). The rotor assembly (20a) is bearingly mounted to the centertube (34) for rotation about the centertube (34). The rotor assembly (20a) includes a rotor shell (26), a cone-stack assembly (24), and a retention-medium sleeve (21) positioned between the cone-stack assembly (24) and the rotor shell (24) and the rotor shell (26) for receiving and retaining particulate matter which is centrifugally from the fluid being "processed" by the centrifugal separator (20). A water-absorbent material is included as part of the retention-medium sleeve (21), whose preferred material is a high-void medium of at lest 70 per cent. An additional retention-medium member formed into a coil-like shape is positioned between the cone-stack assembly (24) and the base (30). The base (30) includes a pair of tangential flow jet nozzles (50,51) which are used for driving the rotor assembly (20a).

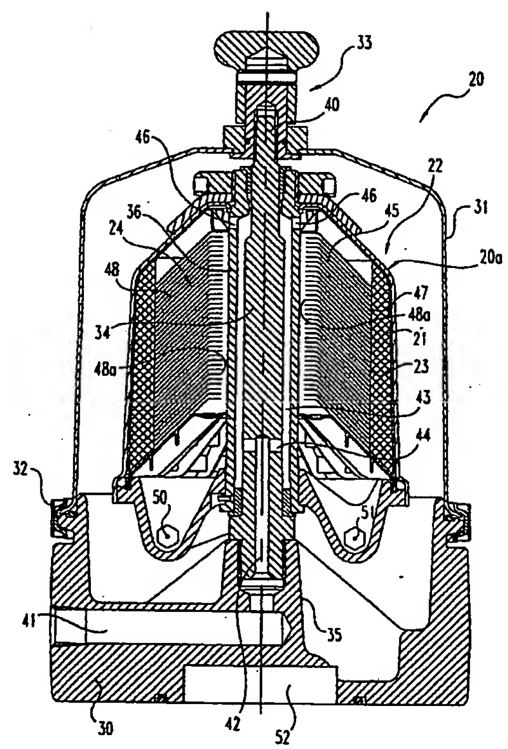

Fig. 1

EP 0 995 496 A2

Description

BACKGROUND OF THE INVENTION

[0001] Th present invention relates gen rally to th design of a centrifugal separator for removing particulate matter from a fluid, such as lubricating oil for a diesel engine or hydraulic fluid. More specifically the present invention relates to the use of a retention medium formed into a generally cylindrical sleeve for use in a cone-stack centrifugal separator for capturing and retaining particulate matter.

[0002] Cone-stack centrifugal separators are disclosed in United States Patent Nos. 5,575,912 and 5,637,217. In each patent a flow path or flow circulation path is described as extending over, around and through a cone-stack assembly comprising a stacked plurality of virtually identical cones with the axial spacing between cones precisely controlled. What is ultimately achieved by the rotation of the cone-stack assembly which is driven as part of the rotor assembly is the separation of particulate matter out of the fluid and the collection of this particulate matter. Periodically, the cone-stack assembly is cleaned, in the case of a reusable cone-stack assembly, or discarded, in the case of a disposable, single-use cone-stack assembly.

[0003] In engine lube-system applications, the particulate matter and debris collected out of the fluid by the cone-stack assembly and by the centrifugal rotation of that assembly is compressed into a dense "sludge cake" that is resistant to reentrainment back into the fluid. In other words, once the particulate matter and debris is separated out of the fluid, it will not normally reenter the fluid due to its manner of being compressed into the sludge cake which basically stays intact.

[0004] Unlike engine lube-system applications, the particulate matter and debris collected by a centrifugal separator in a hydraulic system is typically not formed into the described sludge cake. Whatever particulate matter or debris has accumulated in a hydraulic system has a tendency to reenter the fluid. The tendency for reentrainment back into the fluid is greatest during transient conditions such as during engine startup. During the startup condition, the particle collection zone, which is between the outer peripheral edges of the individual cones of the cone stack and the outer wall of the rotor housing or shell, is subject to high fluid flow/shear/turbulence that can cause substantial reentrainment of "loose" particulate collected in a hydraulic application. In order to prevent, or at least minimize, this reentrainment, the fluid flow and shear in the collection zone must be minimized. A solution is offered by the present invention which includes novel and unobvious structural features and relationships.

[0005] The present invention provides a retention medium which is placed around the outer edge of the cone-stack assembly and against the inside surface of the rotor shell. If a liner is used, the retention medium is placed against the inside surface of th liner. Based upon th typical shapes of cone-stack assemblies and rotor shells, the retention medium is typically formed into the shap of a cylindrical sleeve, with a gen rally uniform wall thickness. There may be a slight taper to this sleeve, but the key to its effectiveness is based upon the fact that the retention medium fills the clearance space (i.e., the particle collection zone) between the outer peripheral edge of the cone-stack assembly and the rotor shell.

[0006] The preferred material for the retention medium is a high-void medium such as a high-loft polyester (non-woven). Alternatively, a knitted metal mesh or reticulated foam can be used. The retention medium provides a matrix for centrifuged particles to collect within and reduces fluid flow and shear during startup by diverting the fluid away from the particle collection zone (i.e., separation zone).

[0007] According to the present invention, once the retention medium is loaded with particulate matter and debris, the retention medium can either be cleaned, if designed for multiple uses, or discarded, if designed as a disposable unit. Generally speaking, the style of retention medium sleeve will coincide with the style of cone-stack assembly, either a multiple-use style or a disposable style. The disposable style of medium retention sleeve, which might also be referred to as a replaceable retention medium sleeve, may be disposed of as a separate unit or disposed of as part of the disposal of the cone-stack assembly.

SUMMARY OF THE INVENTION

[0008] A centrifugal separator for removing particulate matter from a fluid according to one embodiment of the present invention comprises a base, an outer shell assembled to the base, a centertube assembled to the base, and a rotor assembly mounted onto the centertube, the rotor assembly including a retention-medium member constructed and arranged to receive and retain said particulate matter.

[0009] One object of the present invention is to provide an improved centrifugal separator which includes a retention-medium member.

[0010] Related objects and advantages of the present invention will be apparent from the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. 1 is a front elevational view in full section of a centrifugal separator according to a typical embodiment of the present invention.

[0012] FIG. 2 is an enlarged detail of a portion of the FIG. 1 centrifugal separator illustrating the presence of a retention-medium sleeve.

[0013] FIG. 3 is a front elevational view in full section of the FIG. 1 centrifugal separator with a retention-me-

dium coil positioned within a rotor assembly.

[0014] FIG. 4 is a partial, front elevational view in full section of the FIG. 2 retention-medium sleev with water-absorbent fibers added.

DESCRPITION OF THE PREFERRED EMBODIMENT

[0015] For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiment illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended, such alterations and further modifications in the illustrated device, and such further applications of the principles of the invention as illustrated therein being contemplated as would normally occur to one skilled in the art to which the invention relates.

[0016] Referring to FIGS. 1 and 2 there is illustrated a cone-stack, centrifugal separator 20 with a particle-retention medium formed into a generally cylindrical sleeve 21 which is positioned within rotor assembly 20a. More specifically, sleeve 21 is positioned within the particle collection zone 22 which is disposed between and defined by the outer peripheral edge 23 of the cone-stack assembly 24 and the inner surface 25 of the rotor shell 26. If a rotor shell liner is provided, it is positioned at the location of broken line 27. With this structure, the sleeve 21 is positioned adjacent to the inner surface 28 of the liner (i.e., line 27). Since the cone-stack assembly 24 is made up of an axial stack of virtually identical individual cones with a nearly identical spacing between cones, the outer peripheral edge 23 of the cone-stack assembly 24 is basically the outer peripheral edge of each of the individual cones comprising the cone stack. Rotor assembly 20a includes rotor shell 26, cone-stack assembly 24, and sleeve 21, to mention some of the primary components.

[0017] The purpose and function of sleeve 21 is to capture and retain particulate matter and debris which is centrifugally separated out of the fluid being circulated through the centrifugal separator 20. Once the particulate matter and debris is captured, the design of sleeve 21, including the composition and design of the particle retention medium, effectively prevents, but at a minimum substantially reduces, any reentrainment of the captured particulate matter and debris into the circulating fluid. The tendency for reentrainment is greatest during transient conditions such as during engine startup. The detailed operation of a self-driven, cone-stack centrifuge or centrifugal separator is described in United States Patent Nos. 5,575,912 and 5,637,217. U.S. Patent No. 5,575,912, which issued November 19, 1996 to Herman et al., is hereby expressly incorporated by reference herein. U.S. Patent No. 5,637,217, which issued June 10, 1997 to Herman et al., is hereby expressly incorporated by reference herein.

[0018] A bypass circuit centrifuge is disclosed in United States Patent No. 5,575,912. The centrifuge is designed for separating particulate matter out of a circulating liquid and is c nfigur d with a hollow and g nerally cylindrical centrifuge bowl which is arranged in combination with a base plate so as to defin a liquid flow chamber. A hollow centertub axially xtends up through the base plate into the hollow interior of the centrifuge bowl. The bypass circuit centrifuge is designed so as to be assembled within a cover assembly and a pair of oppositely disposed tangential flow nozzles in the base plate are used to spin the centrifuge within the cover so as to cause particles to separate out from the liquid. The interior of the centrifuge bowl includes a plurality of truncated cones which are arranged into a stacked array and are closely spaced so as to enhance the separation efficiency. The stacked array of truncated cones is sandwiched between a top plate positioned adjacent to the top portion of the centrifuge bowl and a bottom plate which is positioned closer to the base plate. The incoming liquid flow exits the centertube through a pair of oil inlets and from there flows through the top plate. The top plate in conjunction with ribs on the inside surface of the centrifuge bowl accelerate and direct this flow into the upper portion of the stacked array of truncated cones. As the flow passes through the channels created between adjacent cones, particle separation occurs as the liquid continues to flow downwardly to the tangential flow nozzles.

[0019] A bypass circuit centrifuge is disclosed in U.S. Patent No. 5,637,217. The centrifuge is designed for separating particulate matter out of a circulating liquid and is configured with a hollow and generally cylindrical centrifuge bowl which is arranged in combination with a base plate so as to define a liquid flow chamber. A hollow centertube axially extends up through the base plate into the hollow interior of the centrifuge bowl. The bypass circuit centrifuge is designed so as to be assembled within a cover assembly and a pair of oppositely disposed tangential flow nozzles in the base plate are used to spin the centrifuge within the cover so as to cause particles to separate out from the liquid. The interior of the centrifuge bowl includes a plurality of truncated cones which are arranged into a stacked array and are closely spaced so as to enhance the separation efficiency. The incoming liquid flow exits the centertube through a pair of oil inlets and from there is directed into the stacked array of cones. In one embodiment, a top plate in conjunction with ribs on the inside surface of the centrifuge bowl accelerate and direct this flow into the upper portion of the stacked array. In another embodiment the stacked array is arranged as part of a disposable subassembly. In each embodiment, as the flow passes through the channels created between adjacent cones, particle separation occurs as the liquid continues to flow downwardly to the tangential flow nozzles.

[0020] One of the aspects of the structures disclosed in the two referenced patents is that both are designed principally for handling lub oil and removing particulate

matter and debris from the lub oil flowing across the cone-stack assemblies through the centrifuges. As was explained in th Background, the particulate matter and debris which is s parated out of th lube oil collects and compacts its lf into what can best be described as a sludge cake. Since this sludge cake basically stays intact as it accumulates and builds, there is little risk that portions of the sludge will separate and enter or disperse back into the flowing or circulating lube oil. Due to the physical properties or characteristics of lube oil sludge (i.e., particulate matter and debris), it is not necessary to provide other devices or structures to hold or capture the sludge as it accumulates. As the sludge builds up, it is compressed into the cake or mass and basically stays intact in that form.

[0021] When a centrifuge or centrifugal separator, preferably with a cone-stack assembly, is used for hydraulic fluid, the particulate matter and debris (i.e., sludge) does not possess the same properties as lube oil sludge. Specifically, a sludge cake does not form when centrifuging hydraulic fluid to separate out particulate matter and debris. The sludge does not accumulate into a mass that basically stays intact. There is therefore a potential for the particulate matter and debris which has already been removed from the hydraulic fluid to reenter that fluid. As described, the greatest tendency for this type of reentrainment to occur is during transient conditions, such as during engine startup.

[0022] In order to address this situation, the present invention provides a particle retention medium which is formed into a generally cylindrical sleeve 21 and installed into a cone-stack centrifugal separator 20. The basic construction of centrifugal separator 20 is similar to the centrifuge structures disclosed in U.S. Patent Nos. 5,575,912 and 5,637,217, except primarily for the addition of sleeve 21. The FIG. 1 illustration also includes the surrounding and enclosing structure of base 30, outer shell 31, annular clamp assembly 32, and cap assembly 33. Also included is the stationary centertube 34 which is threadedly mounted into hub 35 of base 30. Rotor tube 36 which is part of rotor assembly 20a is positioned around and is concentric with centertube 34 and is bearingly supported therewith for rotation of the rotor assembly 20a, including the rotation of cone-stack assembly 24, about centertube 34. The upper tip 40 of centertube 34 is received by cap assembly 33 which helps to maintain the concentric alignment of the annular components of centrifugal separator 20.

[0023] The fluid inlet 41 defined by base 30 delivers the fluid to be "processed" by the cone-stack assembly 24. The fluid flows through main passageway 42 and exits into the interior 43 of rotor tube 36 via connecting passageway 44. The fluid travels upwardly toward the top or tapered end of the cone stack 45 and exits from rotor tube 36 by way of flow ports 46. The fluid flow over and through the cone stack 45 begins adjacent the outer edge 47 of each cone 48 where the fluid flow travels through the cone flow holes 49 and then upwardly and inwardly between adjacent cones 48 (s e FIG. 2). Th fluid flow then travels downwardly in the direction of base 30 between the inner annular dg s 48a of the cones and the outer surfac of rotor tube 36. The xiting fluid at the lower edge of the cone stack 45 is directed through flow jet nozzles 50 and 51 which are direct d tangentially relative to the axis of rotation of the cone-stack assembly 24, for imparting (self-driven) rotary motion to the cone-stack assembly. The spent fluid exiting from the flow jet nozzles 50 and 51 is routed to drain 52. As would be understood, and to complete the construction of centrifugal separator 20, the outer shell 31 is attached to base 30 by means of clamp assembly 32. An interior O-ring seal is used to provide a liquid-tight interface at this location. The space between the outer surface of rotor assembly 20a and the inside surface of outer shell 31 is an air gap which facilitates the free rotation of the rotor assembly 20a relative to the stationary centertube 34 and relative to the remainder of the centrifugal separator 20, noting that the outer shell 31 as well as the base 30 are also stationary relative to the rotation of rotor assembly 20a.

[0024] With continued reference to FIG. 2, the construction details of cylindrical sleeve 21 including the composition of the particle retention medium will now be described. While sleeve 21 has been described as being generally cylindrical, its exact shape is influenced by the shape of the rotor shell 26 and/or any rotor liner, if a rotor liner is provided (see line 27 in FIG. 2). The inner surface 57 of the sleeve 21 is cylindrical and any slight taper to the overall sleeve 21 is due to or corresponds to any taper in the rotor shell or rotor liner. Since each cone 48 is of a virtually identical construction, and since each cone is positioned the same relative to cylindrical rotor tube 36, the outer annular edge 47 of each cone 48 is positioned adjacent inner edge 57 with virtually identical spacing, both radially and axially, which spacing in a radial direction relative to inner surface 57 is minimal.

[0025] The particle retention medium which creates a particle trap is a high-void medium (at least greater than 70 per cent) such as a high-loft polyester, preferably non-woven, a knitted metal mesh, or a reticulated foam, to mention a few of the material options. The use of these types of materials and the specific configuration and shape for sleeve 21 results in a matrix for centrifuge particles to collect within and reduces fluid flow and shear during startup conditions by diverting the fluid flow away from the collection (i.e., separation) zone.

[0026] Based on the testing of various materials, the best performance has been achieved with a high-loft, non-woven polyester material similar to what is used as pre-filter material for heavy duty air filters. The testing which was conducted in order to evaluate the effectiveness of various materials for cylindrical sleeve 21 involved the loading of a centrifuge rotor with dust and then subjecting it to shut down/startup cycles while continuously monitoring particle counts in the test sump with an on-line laser particle counter. The reentrainment ratio

(particl count during shut down divided by particle c unt spik immediat ly after startup) was plotted for various particl sizes. These results enabled selection of th pr ferred material.

[0027] With reference to FIG. 3, an enhancement to the structure of FIG. 1 is illustrated. The enhancement includes the placement of a donut-shaped ring 60 of filtering material between the cone-stack assembly 24 and the flow jet nozzles 50 and 51. The use of this material and the forming of the material into a coil-like shape, as well as its placement within the centrifugal separator, enables ring 60 to function as a type of final filter in order to capture any reentrained debris or particulate matter.

[0028] Another enhancement for cylindrical sleeve 21 is illustrated in FIG. 4. This enhancement includes the addition of water-absorbent pellets 62 or granular powders composed of xanthan, starch, or acrylate superabsorbent polymers. A few of the pellets 62 are illustrated in FIG. 4. Superabsorbent polymers such as those fabricated from polyacrylate and polyacrylamide are frequently used in infant diapers. The sleeve 63 which is created is thus able to capture separated water and prevent it from draining out of the centrifuge during shut down. This is particularly important for hydraulic applications because water is highly undesirable in hydraulic systems. Since water is more dense than oil, the operation of the centrifugal separator separates the water from the oil. Once this separation task is performed, it would be an important enhancement and an improvement to capture and retain the water within the centrifugal separator, specifically within sleeve 63, for later removal when the sleeve 63 is replaced. Replacement of sleeve 21 or of sleeve 63 may be achieved by disassembly of centrifugal separator 20 and removal of the sleeve as a separate component. The sleeve, 21 or 63, may also be removed as part of the removal of a replaceable cone-stack assembly.

[0029] While the invention has been illustrated and described in detail in the drawings and foregoing description, the same is to be considered as illustrative and not restrictive in character, it being understood that only the preferred embodiment has been shown and described and that all changes and modifications that come within the spirit of the invention are desired to be protected.

Claims

1. A centrifugal separator for removing particulate matter from a fluid, said centrifugal separator comprising:

   a base;
   an outer shell assembled to said base;
   a centertube assembled to said base;
   a rotor assembly mounted onto said centertube, said rotor assembly being construct d and arranged to rotate about said centertube, said rotor assembly including a retention-medium member constructed and arranged to receive and retain said particulat matter.

2. A centrifugal separator according to claim 1 wherein said rotor assembly further includes a rotor shell with an inside surface and said retention-medium member is positioned adjacent said inside surface.

3. A centrifugal separator according to claim 1 wherein said rotor assembly includes a cone-stack assembly with a plurality of cones, each cone having an outer peripheral edge, said retention-medium member being positioned between said outer peripheral edges and said outer shell.

4. A centrigual separator according to claim 2 wherein said rotor assembly further includes a cone-stack assembly with a plurality of cones, each cone having an outer peripheral edge, said retention-medium member being positioned between said outer peripheral edges and said inside surface.

5. A centrifugal separator according to claim 3 or claim 4, wherein said retention-medium member has a substantially cylindrical shape.

6. A centrifugal separator according to claim 1 or claim 2 or claim 5, wherein the material used for said retention-medium member is a high-void medium of at least 70 per cent.

7. A centrifugal separator according to claim 6, wherein the material for said retention-medium member is a high-loft, non-woven polyester.

8. A centrifugal separator according to claim 1 or claim 2 or claim 7, wherein the material for said retention-medium member includes a water-absorbent material.

9. A centrifugal separator according to claim 2 of claim 8, wherein said rotor assembly further includes an annular retention-medium coil.

10. A centrifugal separator according to claim 9, wherein said base includes at least one jet flow nozzle, said annular retention-medium coil being positioned between said cone-stack assembly and said at least one jet flow nozzle.

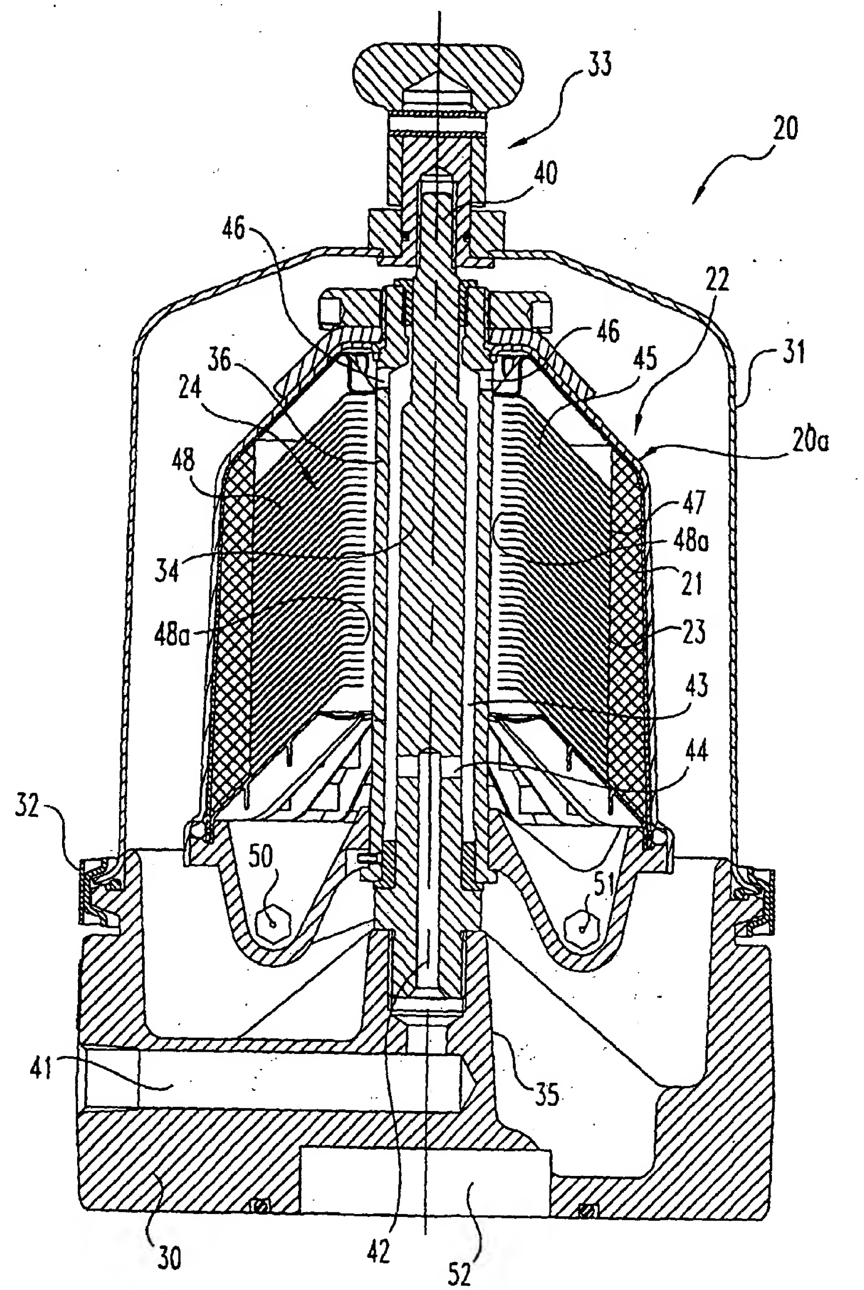
33
20
40
46
22
46
45
31
36
24
20a
48
47
48a
34
21
48a
23
43
44
32
50
51
41
35
30
42
52

Fig. 1

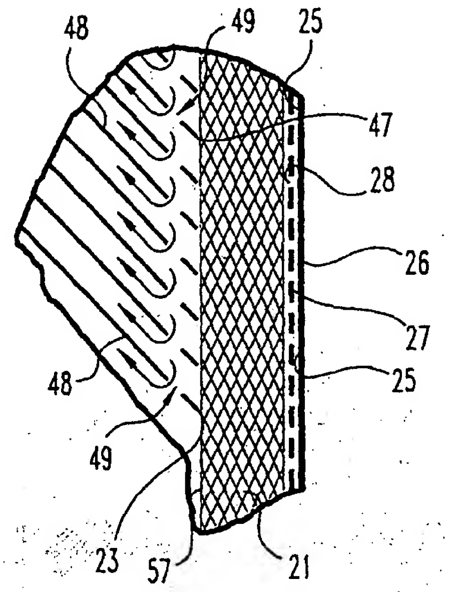
48
49
25
47
28
26
27
25
48
49
23
57
21

Fig. 2

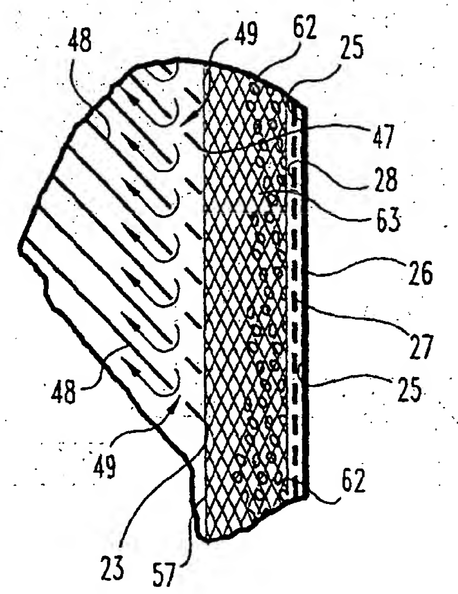
48
49
62
25
47
28
63
26
27
25
48
49
62
23
57

Fig. 4

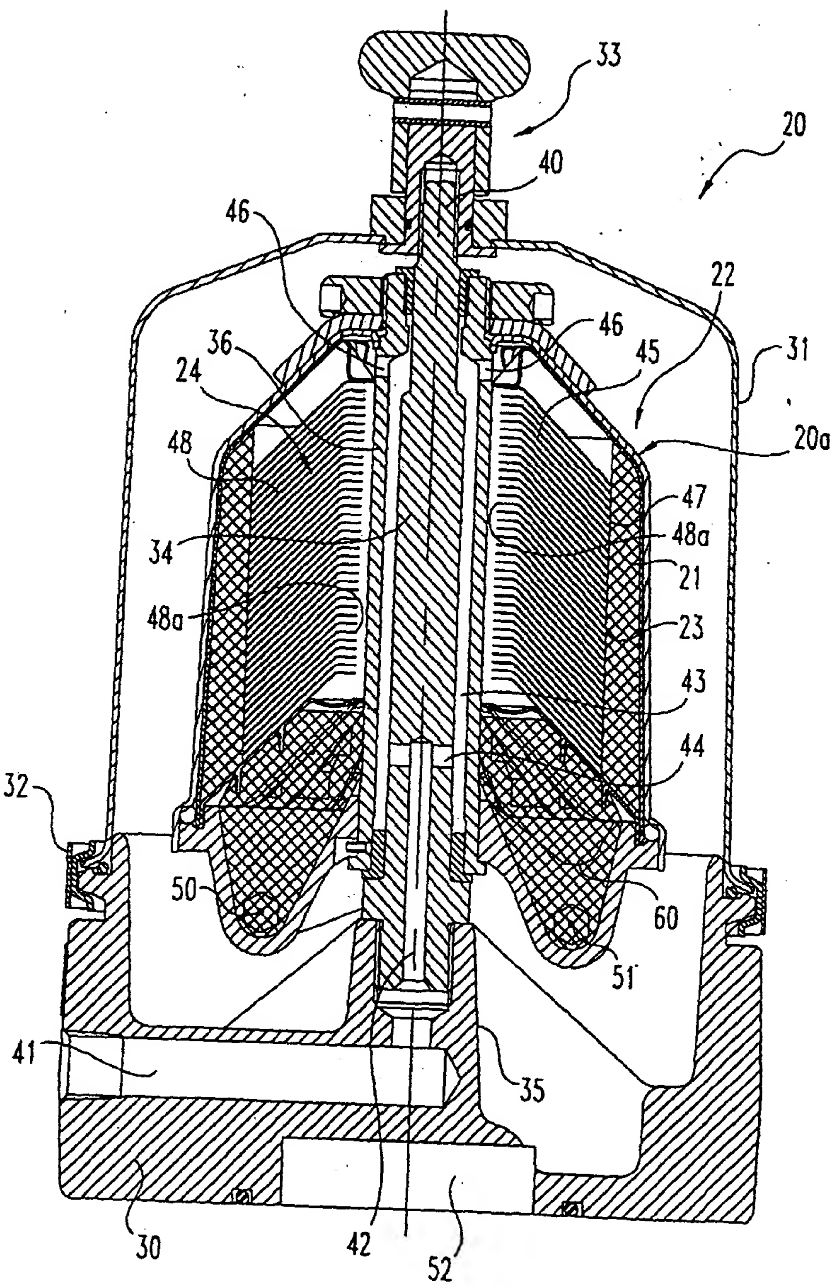
33
20
40
46
22
46
36
45
31
24
20a
48
47
48a
34
21
48a
23
43
44
32
50
60
51
41
35
30
42
52

Fig. 3